A NEW APPROACH TO BUCKLING DETECTION IN OFFSHORE PIPELINE LAYING

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1. ABSTRACT

This paper discusses a novel concept of detecting local buckling in new offshore pipelines.

The method employs two tethered crawlers, one located close to the lay barge end and the other beyond the point where buckling is expected to occur. The tractors can "walk" in synch along the pipe. As both tractors are self-propelled, this proposed new method will remove the need to have a cable in tension. By fitting the second tractor with a camera and an array of sensors, video images and geometrical measurements of the newly laid pipe can be obtained in real time.

2. THE PROBLEM OF BUCKLING IN OFFSHORE PIPELINE LAYING

Using either S-lay or J-lay techniques, submarine pipelines have been installed all over then world, in water depths down to 2000 m and beyond, and in diameters ranging from 76 mm (3") up to 1270 mm (50"). Both the S-lay and the J-lay methods present the risk of pipeline buckling and both employ various measures to prevent it; however, the risk of buckling can never be completely removed.

Local buckling, which in its extreme form can result in the total collapse of the pipe cross section, represents one of the most severe failure modes for submarine pipelines. The buckling can appear as a consequence of the bending moment (over the stinger or at the touch down point), of the external pressure, or as a combination of both. For deep waters and ultra deep waters, the buckling caused by the external pressure will be the governing failure mode.

Local buckling of newly laid pipelines can be caused by a variety of reasons:

- Line pipe out of specs
- Mismatch of welds
- Step changes in wall thickness
- Step changes in yield limit
- Presence of inline items such as Tees or Y-Pieces

- Excessive bending strains caused by variations of the operating parameters outside the design conditions

It is critical than any buckling is detected as soon as possible. Providing that the occurrence of local buckling is detected during the installation of the pipe, the repair can be carried out with relative ease. In the case of a dry buckle, the damaged section of the pipe is usually recovered back to the laying vessel, where it is removed and the installation work can restart without significant costs overruns or delays to the schedule.

In the case of a wet buckle it may be necessary to lay down the pipe on the seabed, remove the damaged section by a subsea pipe cutter, connect an emergency recovery head to the pipeline and recover the pipe to the laying vessel. In most such cases, the pipeline must be dewatered before it can be recovered. All these activities will result in significant additional costs and increased delays.

There are serious risks if the local buckling is not detected until the pipe is fully installed. In this case, if the pipeline is short or the buckle is located close to one of the ends, it may be possible to use a lay barge to recover the pipeline, remove and replace the damaged section and reinstall the pipeline. In all other cases an inline repair will need to be carried out using an approved repair system, operated either by divers (down to approx. 200 m) or by ROV (down to approx. 600 m). These methods tend to be very expensive, but at least offer a viable solution. If the damage occurs in ultra deep waters at depths for which there are no proven repair systems, the consequences can be disastrous, both in economical terms and in delays to the schedule.

3. CURRENT METHODS OF BUCKLING DETECTION; APPLICABILITY AND LIMITATIONS

There are several methods that can be employed to detect buckles as they occur:

- Direct internal methods: gauging plate
- Direct external methods: visual inspection by ROV
- Indirect methods: detection by parameter control; acoustic noise; escaped air.

One of the most employed methods of buckling detection is to pull a gauging plate using a tension cable. This method presents several drawbacks, including: relatively low sensitivity; significant number of false alarms; increased cable weight and friction for deep pipelines. The most significant risk is that of a broken wire, the subsequent “fishing activity” to recover the plate can be a very frustrating experience with no guaranteed results and serious delays may be encountered.

Where the use of an internal gauging plate is considered too risky, an ROV can be used to continuously follow and video monitor the newly laid pipe just after the touch down point. In addition to the significant additional costs related to the use of an ROV and a team of operators exclusively dedicated to this activity, this method depends on very good visibility and may not be of any use where the water is very dirty, or the pipe sinks in a soft seabed.

All indirect methods depend on close monitoring of operating parameters, e.g. top tension, top angle, volume of air escaping or entering the pipe at the barge end, listening to the noise generated by a propagating buckle, etc. All these methods have severe limitations, due to the difficulty of monitoring all necessary parameters with the required degree of precision in the operating conditions encountered on a real barge. After all, the probability of an optimally positioned laying barge operating quietly under a clear blue sky with only a gentle breeze and with no discernable undercurrents or unexpectedly large free spans must be pretty low.

4. A NEW APPROACH

In response to the challenges presented by the current buckle detection methods, DPT is working on a new approach. This new method employs two tethered bristle tractors (also known as pipeline crawlers); one is located close to the barge end, the other beyond the point were buckling is expected to occur. The two crawlers “walk” in synch along the pipe, as it is being laid. As both tractors are self-propelled, this proposed new method will remove the need to have a cable in tension.

The first crawler will be fitted with a quick-disconnect umbilical. This crawler will also support the weight of the connecting umbilical that will provide the necessary power and signal cables to the second crawler. By fitting the second crawler with a camera and an array of sensors, video images and geometrical measurements of the newly laid pipe can be obtained in real time

5. NEW EQUIPMENT

This new method is based on the use of DPT pipeline crawlers using our patented bristle-tractor technology. The crawlers are self propelled and do not depend on the product flow.

DPT crawlers operate on the principle that an oversized circular brush pushed inside a tubular conduit behaves in an asymmetric way, i.e. it is easier to push the brush forward than to pull it back. Where two sets of such brushes are interconnected by a mechanism that generates a reciprocating motion towards and away from each other, the whole assembly moves in successive steps.

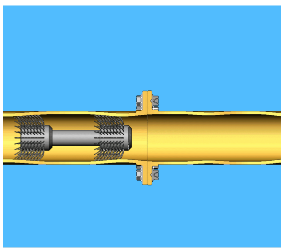

Fig. 1

The tractor advances as a result of a series of cycles. At the beginning of a cycle the cylinder is fully contracted, front and rear bristles are stationary and inclined backwards.

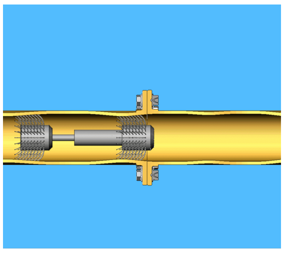

Fig. 2

The resistance provided by the rear bristles is greater than the force required to push the front bristles forward. As the cylinder starts to expand, the front bristles move forward.

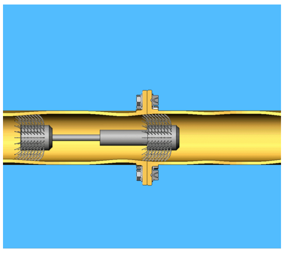

Fig. 3

The cylinder is fully expanded. The front bristles have advanced by one cylinder stroke and both rear and front bristles are stationary

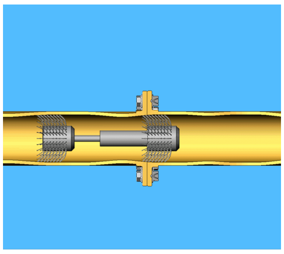

Fig. 4

The cylinder begins to contract. The front bristles now provide the grip and the rear bristles are pulled forward.

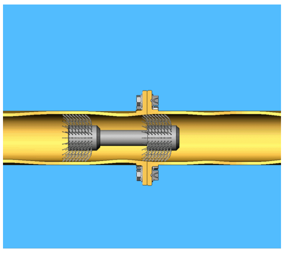

Fig. 5

The cylinder is fully contracted and the cycle is complete.

DPT crawlers are reversible and bi-directional, flexible yet powerful. By customising the material, size, number and pattern of bristles, tethered DPT crawlers can achieve multi-ton pulling forces. They are able to travel through vertical pipes, negotiate tight bends, overcome significant obstacles and provide a firm platform for carrying out a multitude of tasks.

This unique combination of properties enables DPT crawlers to travel through many pipes that would otherwise be considered unpiggable.

6. NEW METHOD

This new method for detecting pipeline buckling utilises two DPT crawlers, linked by a "connecting umbilical". The top crawler is located close to the barge end. The bottom crawler is located well beyond the area where buckling is expected to occur. Both crawlers are linked to the control room by a "top umbilical" fitted to the top crawler by means of a quick-disconnect coupling.

When a new pipe section needs to be welded, the top umbilical is disconnected and the top crawler is "parked" close to the pipe end. In this passive mode, the top crawler is able to support its own weight plus the weight of the connecting umbilical without any power requirements, whilst the bottom crawler is parked beyond the touch down area at risk from buckling. The connecting umbilical does not support the weight of the bottom crawler, it just lays in the pipe under its own weight (see fig. 6).

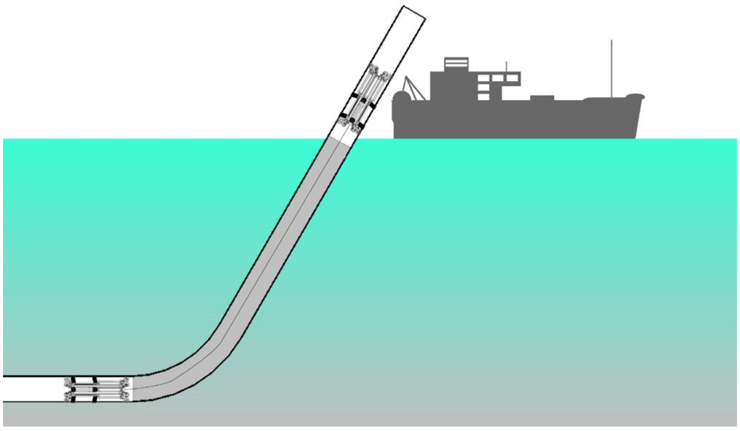

Fig. 6 General layout showing two DPT tractors inside a submarine pipeline being laid from a barge

The top umbilical is threaded through the new pipe to be welded and reconnected to the top crawler before the two pipes are attached, then the weld is completed and inspected. The barge advances by a distance corresponding to the length of the pipe section newly attached. The tractors are still parked in their original positions (see fig. 7).

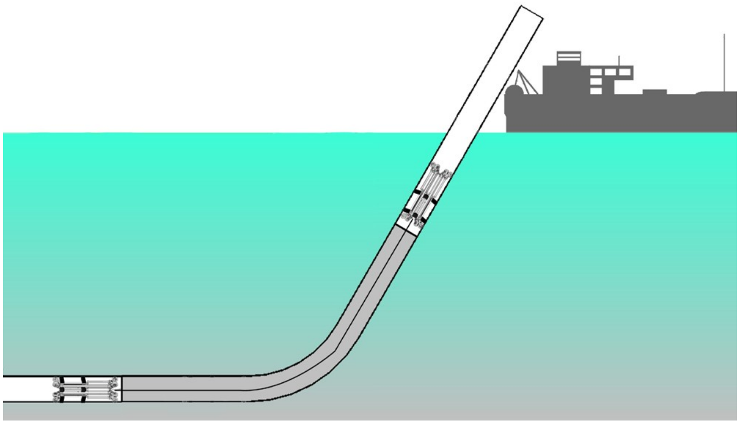

Fig. 7 A new length of pipe has been welded, the barge advanced and a new pipe section has been laid on the sea bottom.

The two identical crawlers now move in a synchronised way, until the top crawler reaches a position close to the end of the pipe (see fig. 8). At this point both crawlers stop and the cycle of attaching a new section of pipe is ready to be repeated.

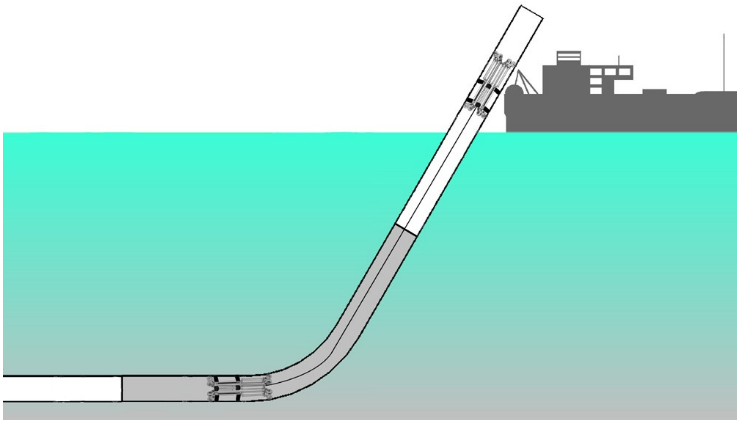

Fig. 8 Both DPT crawlers advance and the bottom crawler inspects the newly laid section

7. BENEFITS OF NEW APPROACH

The proposed method enables the operators of the pipe laying barge to obtain video images and detect buckling in real time. A complete internal video inspection of the newly laid pipeline can be provided to the pipeline operator with no significant additional costs. By providing the bottom crawler with adequate sensors, similar to that of a calliper pig, the bottom crawler can also generate a complete geometrical profile of the new pipeline.

A material difference between the proposed method and that of pulling a gauging plate is that the connecting umbilical is not in tension. The umbilical only provides the required power to the bottom crawler and carries the video and sensor signals to the control room. The weight of the connecting umbilical is supported by the top crawler.

DPT crawlers are designed with multiple redundant systems and are built using robust, proven components. In the unlikely event of power failure or equipment malfunction, the connecting umbilical is capable to pull out the bottom crawler. The top crawler will also be designed to be fail-proof. With the top umbilical disconnected, and even in the event of equipment malfunction, the top crawler will still be able to stay parked in the top section of the pipe and withstand the load imposed by the combined weight of the bottom crawler and the connecting umbilical.

8. SUMMARY AND CONCLUSION

The proposed method offers pipe laying companies a new approach to buckling detection in newly laid pipelines. This new technology overcomes many of the limitations of the other methods currently available on the market. In addition, the proposed method can provide a full internal video inspection or a geometric survey of the pipeline in a very cost effective way.

9. REFERENCES

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(2) Asle Venås, “Buckle Detection During Installation of Deep Water Pipelines”, OPT 2004
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